

# **JOLTS Variance Estimation: Accounting for CES-JOLTS Alignment**

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## **Abstract**

The Bureau of Labor Statistics produces a monthly measure of labor demand and employment dynamics called the Job Opening and Labor Turnover survey (JOLTS). The JOLTS survey has aligned its implied employment change (hires minus separations) to the published CES employment change to enhance the reliability of JOLTS estimates. This change in estimation methodology, however, is not presently accounted for in JOLTS variance estimation.

To address this shortcoming, an extension of the current Balanced Repeated Replication technique has been devised that will attempt to fully account for the CES-JOLTS alignment in JOLTS variance estimation. In essence, the extension consists of applying the CES-JOLTS alignment procedure to each replicate estimate and then building an estimate of variance from the aligned replicate estimates.

The proposed extension has been applied to historical JOLTS micro-data thus allowing a comparison to be made between the estimates of variation without accounting for CES-JOLTS alignment and the proposed extension of the Balanced Repeated Replication that does.

**Key words:** Job Opening and Labor Turnover (JOLTS) survey; Current Employment Statistics (CES) survey; Balanced Repeated Replication (BRR) variance estimation.

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## CES-JOLTS Alignment

The Job Opening and Labor Turnover Survey (JOLTS) is a survey of approximately 16,000 business establishments whose estimates are produced and published monthly by the Bureau of Labor Statistics. JOLTS represents an attempt to measure labor demand (in the form of Job Openings) as well as employment flows (in the form of Hires and Separations) at the national, regional and major industry level. JOLTS is a natural complement to the Bureau's Current Employment Statistics (CES) survey which attempts to measure monthly employment change.

JOLTS employment estimates are benchmarked to estimated CES employment levels since the CES employment levels are based on a significantly larger sample size than are JOLTS estimates (approximately 600,000 establishments in CES vs. 16,000 in JOLTS). JOLTS measures of employment flow (hires minus separations) are conceptually equivalent to CES employment change and therefore it is a reasonable expectation that JOLTS employment flow trends should closely follow CES employment change trends over time. JOLTS has drawn from the strength of the larger CES sample size using the CES-JOLTS alignment procedure to, in effect, "benchmark" annual JOLTS employment flow to the annual CES employment trend.

While JOLTS estimates have drawn from the strength of the larger CES estimates by benchmarking employment levels and employment flow trends, JOLTS variance estimates have not. The current JOLTS variance estimator does not account for the CES-JOLTS alignment procedure in any way. The remainder of this paper will discuss the current JOLTS variance estimator, it will provide a proposed JOLTS variance estimator that does account for the CES-JOLTS alignment, and it will briefly compare the variance estimates produces for the current and proposed variance estimate methodologies.

## Current JOLTS Variance Estimator

JOLTS shares the same sampling scope and frame as the CES survey. The primary sampling unit in JOLTS is the individual business establishment. The JOLTS sample is stratified by region (as defined by U.S. Census region), establishment size class, and by North American Industrial Classification (NAICS) super-sector.

Below are the inputs into JOLTS estimation:

- $S_i$  is the sample of establishments  $\{e : e \in S_i\}$  for each NAICS super-sector industry  $i$ ,  $i \in I_s$ ,
- $S = \{S_i : i \in I_s\}$  is the sample of establishment for JOLTS,
- $w_{iet}$  is the final estimation weight corresponding to the industry/establishment  $(i,e)$ , at time  $t$ ,
- $\mathbf{y}_{ie} = \{y_{iet} : t = 1, \dots, T\}$  is a vector of hires for months  $t=1, \dots, T$  in industry/establishment  $(i,e)$ ,
- $\mathbf{x}_{ie} = \{x_{iet} : t = 1, \dots, T\}$  is a vector of separations for months  $t=1, \dots, T$  in industry/establishment  $(i,e)$ ,

JOLTS industry estimates are derived using a standard Horvitz-Thompson ratio estimator for each industry strata. The basic form of JOLTS estimates are then as follows:

- $\tilde{y}_{it} = \sum_{e \in S_i} w_{iet} y_{iet}$  basic JOLTS estimator of hires for months  $t=1, \dots, T$  in industry  $i$
- $\tilde{x}_{it} = \sum_{e \in S_i} w_{iet} x_{iet}$  basic JOLTS estimator of separations for months  $t=1, \dots, T$  in industry  $i$

The estimation of sample variance for the JOLTS survey is currently being accomplished through use of the Fay's method of Balanced Repeated Replication (BRR). This replication technique uses the full sample but with unequal weighting. The sample variance is calculated by measuring the variability of the BRR estimates. The sample units in each cell—where a cell in this context is based on industry and size classification—are divided into two random groups. The basic BRR method is applied to both groups. The subdivision of the cells is done systematically, in the same order as the initial sample selection. Weights for units in the half sample are multiplied by a factor of  $1 + \alpha$  whereas weights for units not in the half sample are multiplied by a factor of  $1 - \alpha$ , where  $\alpha=0.5$ .

First we assign all JOLTS sample units to one of two random groups (RG). We then obtain a Hadamard matrix (H) of order 114 with entries of +1 and -1. This matrix is transposed resulting in row  $\alpha$  denoting half-sample and column  $l$  denoting strata (19 industries x 6 establishment sizes). Each column in the Hadamard matrix thus corresponds to the 114 industry x establishment size class strata. Each variance strata is then assigned to a column of the Hadamard matrix and each sample unit is assigned to a half-sample (that is, a row of the Hadamard matrix).

We then calculate a finite population correction (fpc) factor for each strata. The fpc is calculated as:

$$f_{t,h} = \frac{r_{t,h}}{\sum_{i=1}^{n_h} w_i^{SEL}} \text{ where } r_{t,h} \text{ is the number of units reporting employment in allocation stratum } h \text{ at time } t, \text{ and } n_h$$

is the number of sample units in allocation stratum  $h$ . The variable  $w_i^{SEL}$  is the sample selection weight of sample unit  $i$ . The fpc of the allocation stratum is added as a variable to all sampled units within the stratum. We then adjust the weight for every unit for each replicate as follows:

1.  $w_{i,\alpha}^{SEL} = (1 + \gamma \sqrt{1 - f_{t,h}}) * w_i^{SEL}$  if  $H(\alpha, 1) = RG_{i,l}$ ,
2.  $w_{i,\alpha}^{SEL} = (1 - \gamma \sqrt{1 - f_{t,h}}) * w_i^{SEL}$  otherwise,

where:

$i$	is the establishment unit,
$\alpha$	replicate,
$w^{SEL}$	selection weight,
$\gamma$	Fay's factor (0.5)
$f_{t,h}$	Finite correction factor at time $t$ in allocation stratum $h$ .

We produce an estimate for each of the 114 replicates. We then find the standard error of the replicate estimates (V) where the Fay's method generalization of variance is calculated as  $\frac{V}{(1-k)^2}$ , and  $k=0.5$ .

## Proposed Variance Estimator

The variance methodology outlined above is adequate to produce variance estimates of JOLTS estimates in their basic form. However, the introduction of the CES-JOLTS alignment procedure as altered the basic JOLTS estimation form.

The CES-JOLTS alignment requires addition inputs:

- $Z_{it}^{CES}$  the CES seasonally adjusted estimate for employment change in month  $t$ , for industry  $i$
- $\tilde{\mathbf{y}}_i = \{\tilde{y}_{it} : t = 1, \dots, T\}$  the historical hires estimates for industry  $i$
- $\tilde{\mathbf{x}}_i = \{\tilde{x}_{it} : t = 1, \dots, T\}$  the historical separations estimates for industry  $i$
- $\mathbf{x}_i^{SA}$  and  $\mathbf{x}_i^S$  the X-11 ARIMA estimates of seasonally adjusted and seasonal components of separations in industry  $i$  based on basic estimators  $\tilde{\mathbf{x}}_i$
- $\mathbf{y}_i^{SA}$  and  $\mathbf{y}_i^S$  the X-11 ARIMA estimates of seasonally adjusted and seasonal components of hires in industry  $i$  based on basic estimators  $\tilde{\mathbf{y}}_i$

Using the inputs listed above, the CES-JOLTS alignment procedures calibrates the seasonally adjusted JOLTS employment change ( $\mathbf{y}_i^{SA} - \mathbf{x}_i^{SA}$ ) with the CES seasonally adjusted estimate for employment change ( $Z_{it}^{CES}$ ) such that the basic form of JOLTS estimates are thus calculated as follows:

$$\hat{y}_{it} = y_{it}^{SA} + \frac{y_{it}^{SA}}{y_{it}^{SA} + x_{it}^{SA}} \times [Z_{it}^{CES} - (y_{it}^{SA} - x_{it}^{SA})] + y_{it}^S \quad \text{for hires and}$$

$$\hat{x}_{it} = x_{it}^{SA} - \frac{x_{it}^{SA}}{y_{it}^{SA} + x_{it}^{SA}} \times [Z_{it}^{CES} - (y_{it}^{SA} - x_{it}^{SA})] + x_{it}^S \quad \text{for separations.}$$

To apply the correct and asymptotically unbiased BRR variance estimator one has to recalculate  $\hat{y}_{it}$  and  $\hat{x}_{it}$  using BRR weights for every BRR sub-sample. Suppose for replicate b,  $w_{ist}^{(b)} = 1.5 * w_{iet}$  if  $(i, e) \in S^{(b),1}$  and  $w_{ist}^{(b)} = 0.5 * w_{iet}$  if  $(i, e) \in S^{(b),2}$ ,  $S^{(b),1} \cup S^{(b),2} = S$ . Then the estimates for replicate b are defined by:

$$\tilde{y}_{it}^{(b)} = \sum_{e \in S_i^{(b)}} w_{iet}^{(b)} y_{iet} \quad \text{the estimator of hires for months } t=1, \dots, T \text{ in industry } i, \text{ and}$$

$$\tilde{x}_{it}^{(b)} = \sum_{e \in S_i^{(b)}} w_{iet}^{(b)} x_{iet} \quad \text{the estimator of separations for months } t=1, \dots, T \text{ in industry } i$$

We then define  $\mathbf{y}_i^{SA,(b)}$  and  $\mathbf{y}_i^{S,(b)}$  as the X-11 ARIMA estimates of seasonally adjusted and seasonal components of hires in industry i, based on  $\tilde{\mathbf{y}}_i^{(b)} = \{\tilde{y}_{it}^{(b)}, t=1, \dots, T\}$  while defining  $\mathbf{x}_i^{SA,(b)}$  and  $\mathbf{x}_i^{S,(b)}$  as the X-11 ARIMA estimates of seasonally adjusted and seasonal components of separations in industry i, based on  $\tilde{\mathbf{x}}_i^{(b)} = \{\tilde{x}_{it}^{(b)}, t=1, \dots, T\}$ . For the purposes of variance estimation, it probably suffices to use the same model that was used for the original data or, which is less exact but even simpler, use X-11 without ARIMA extrapolation.

Then the final  $b^{th}$  replicate estimator for the hires in industry i can be found using:

$$\hat{y}_{it}^{(b)} = y_{it}^{SA,(b)} + \frac{y_{it}^{SA,(b)}}{y_{it}^{SA,(b)} + x_{it}^{SA,(b)}} \times [Z_{it}^{CES} - (y_{it}^{SA,(b)} - x_{it}^{SA,(b)})] + y_{it}^{S,(b)}.$$

Similarly for separations the final  $b^{th}$  replicate estimator for the separations in industry i can be found using

$$\hat{x}_{it}^{(b)} = x_{it}^{SA,(b)} - \frac{x_{it}^{SA,(b)}}{y_{it}^{SA,(b)} + x_{it}^{SA,(b)}} \times [Z_{it}^{CES} - (y_{it}^{SA,(b)} - x_{it}^{SA,(b)})] + x_{it}^{S,(b)}.$$

In this case, under general regularity assumptions, the BRR variance estimator is asymptotically unbiased. Once all the  $\hat{y}_{it}^{(b)}$  and  $\hat{x}_{it}^{(b)}$  values have been derived, the remainder of the BRR variance calculation is identical to the current methodology.

At present, we do not have an estimate of  $\text{var}(Z^{CES})$  from the CES program. In the future we may try to approximate the variance of the seasonally adjusted employment change using a non-seasonally adjusted estimate since a seasonally adjusted variance may not be available. At present, however, the variance of the CES seasonally adjusted employment change is not accounted for in JOLTS variance estimation but the variance of the CES seasonally adjusted employment change can be expected to be an order of magnitude less than the other JOLTS-related components.

## Comparison of Variance Estimators

Variance estimates have been successfully produced utilizing the proposed variance estimator outlined in the previous section. JOLTS produces for each month a standard error value for all estimates. For JOLTS, confidence intervals are constructed and significance tests are determined using the median standard error of the estimate over the course of the survey.

The median standard errors of the current variance estimation methodology and the proposed variance estimation methodology are highly correlated at the Industry level. The correlations between the current and proposed variance methodologies for each JOLTS variable across industry are detailed below:

Variable	Correlation ( $\rho$ )
Job Openings	99.71%
Hires	99.30%
Quits	99.87%
Layoffs and Discharges	99.54%
Other Separations	99.71%
Total Separations	99.65%

The median standard errors of the current and proposed variance methodologies for each JOLTS variable across industry for the period 2001-2014 are detailed below. The column entitled 'P/C' represents the ratio of the proposed median standard error relative to the current median standard error:

Median Standard Errors			
Variable	Current	Proposed	P/C
Job Openings	302,967	346,568	1.14
Hires	317,255	290,193	0.91
Quits	186,265	198,661	1.07
Layoffs and Discharges	246,736	232,376	0.94
Other Separations	66,068	66,959	1.01
Total Separations	323,068	290,488	0.90

In the alignment procedure there are two JOLTS variables that are directly influenced: Hires and Total Separations. The remaining JOLTS variables are indirectly influenced. Aligned Job Opening estimates are derived indirectly using the estimated relationship between Hires and Job Openings. Aligned Quits, Layoffs and Discharges, and Other Separations are derived indirectly using the estimated proportion of Quits, Layoffs and Discharges, and Other Separations relative to Total Separations.

From the Median Standard Error table above, the impact of the proposed variance methodology on those variables directly influenced by CES-JOLTS alignment (Hires and Total Separations) is an approximate reduction in the median standard errors of 10 percent. It appears that borrowing strength from the CES employment change reduces a portion of the variance of JOLTS estimates for Hires and Total Separations. Those variables that are indirectly influenced by the CES-JOLTS alignment, in contrast, show a slight increase in median standard error. It appears that the CES-JOLTS alignment procedure adds to the variability of Job Openings and Quits, with a negligible impact on Layoffs and Discharges and Other Separations. Users of JOLTS data would be better served and informed with a variance estimator that accounts for the CES-JOLTS alignment, however, whether by having access to reduced variance estimates for those variables directly influenced by the CES-JOLTS alignment or by having access to increased variance estimates of the variables indirectly influenced by CES-JOLTS alignment.

## Summary

JOLTS estimates are currently able to borrow from the strength of the much larger CES sample using the CES-JOLTS alignment procedure. However, JOLTS variance estimation at present is unable to do so. This paper proposes methodology that can do so. Although the impact of the proposed variance estimator is modest, there does appear to be a reduction in variance estimates for those variables directly affected by the CES-JOLTS alignment as well as a slight increase in variance estimates for those variables indirectly affected by the CES-JOLTS alignment. Regardless of the nature of the impact on JOLTS variance estimates, JOLTS data users will be better informed when using variance estimates that accounts for CES-JOLTS alignment.

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